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Range extension and review of the conservation status of the freshwater mussel *Alasmidonta mccordi* Athearn, 1964 (Bivalvia, Unionidae) in the Coosa River drainage of Alabama and Georgia

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Abstract

The Coosa Elktoe, *Alasmidonta mccordi* Athearn, 1964, was previously known only from the type specimen collected in the Coosa River, St. Clair County, Alabama. Based on the discovery of five previously misidentified specimens in three museum lots, we extend the distribution of *A. mccordi* into the Etowah and Conasauga Rivers, tributaries of the Coosa River in northwest Georgia. Shell morphology of these museum specimens compare favorably with the only known specimen of the species. The conservation status of *A. mccordi* is examined in light of its wider historical distribution in the Coosa River drainage. We include recommendations for future research to detect extant populations of this presumed extinct freshwater mussel.

Keywords

Conasauga River, Coosa Elktoe, Etowah River, extinct species

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Introduction

The Coosa River is one of five large river systems that make up the Mobile Basin, which has tributaries that extend from the southern terminus of the Appalachian Mountains and Interior Low Plateau south to the Gulf of Mexico in parts of Alabama, Georgia, Mississippi, and Tennessee. The Mobile Basin has long been recognized as a hot spot for endemism and aquatic biodiversity, including turtles, fishes, mussels, and snails, and exceeds that of any other area of comparable size in North America (Lydeard and Mayden 1995). Williams et al. (2008) reported 73 species of freshwater mussels (Margaritiferidae and Unionidae) from the Mobile Basin in Alabama, Georgia, Mississippi, and Tennessee, of which 54 occur in the Coosa River drainage of Alabama, Georgia, and Tennessee. Unfortunately, much of this diversity is now threatened or endangered, with three species presumed to be extinct (Garner et al. 2004; Williams et al. 2008). The primary threat to aquatic fauna in the Mobile Basin has been the impoundment of most of the large river habitat for power generation, navigation, and flood control.

The remaining riverine habitat has experienced degradation from sedimentation, nonpoint and point-source pollution, and aquatic invasive species.

The freshwater mussel (Unionidae) *Alasmidonta mccordi* Athearn, 1964, Coosa Elktoe, was first collected by Herbert D. Athearn from the Coosa River, St. Clair County, Alabama, on 2 September 1956. Athearn found only one specimen despite extensive collecting before the last reach of the Coosa River was impounded by Alabama Power Company's Neely Henry Dam in 1966 (Williams et al. 2008). This specimen was collected alive from shallow, swift water in substrate composed of sand and gravel with rock debris from an old navigation dam (Athearn 1964). The original description of *Alasmidonta mccordi* as a new species, based on a single specimen, was published by Athearn (1964). The validity of *A. mccordi* was never in question because of its distinctive shell morphology that distinguishes it from other unionids in Mobile Basin and adjacent river systems (Clarke 1981; Williams et al. 2008).

Methods

We discovered a specimen of *Alasmidonta mccordi* from Georgia in the University of Michigan Museum of Zoology cataloged as *Strophitus rugosus* (Swainson, 1822), a synonym of *Strophitus undulatus* (Say, 1817), which is a Mississippi Basin species. This led us to utilize the Invert-E-Base website (https://invertebase.org/portal/) to query museum collections for additional material. We searched for freshwater mussels of the genus *Alasmidonta* Say, 1818, plus two related and morphologically similar genera, *Lasmigona* Rafinesque, 1831, and *Strophitus* Rafinesque, 1820, from the Coosa River drainage in Georgia, Alabama, and Tennessee that had been cataloged as species that were no longer recognized or were not native to the Mobile Basin. Those known to inhabit the Coosa River drainage, including their synonyms, were presumed to be identified correctly and excluded. The small number of remaining museum lots consisted of those that were recognized species or their accepted synonyms that were not native to the Coosa River drainage. We selected those lots for further investigation to determine their identity. We utilized shell material housed in natural history museums including Academy of Natural Sciences of Drexel University (ANSP; formerly Academy of Natural Sciences of Philadelphia), Philadelphia, Pennsylvania; Canadian Museum of Nature, Mollusks (CMNML; formerly National Museums of Canada), Ottawa, Ontario; Delaware Museum of Natural History (DMNH), Wilmington; Museum of Comparative Zoology (MCZ), Harvard University, Cambridge, Massachusetts; McClung Museum of Natural History and Culture (MMNHC), University of Tennessee, Knoxville; Ohio State University Museum (OSUM), Columbus; Florida Museum of Natural History, University of Florida (UF), Gainesville; and University of Michigan Museum of Zoology (UMMZ), Ann Arbor.

Results

Family Unionidae

***Alasmidonta mccordi* Athearn, 1964**
Figure 1

New records. UNITED STATES OF AMERICA – **Georgia** • county unknown, Etowah River; [1800s]; Charles M. Wheatley collection; ANSP 126760, 1 specimen (2 valves), dry shell, length 64 mm (Fig. 2) • Whitfield County, Conasauga River, Tilton; [34.6665, −084.9282]; 1930; Calvin Goodrich and Henry van der Schalie leg.; UMMZ 51011, 1 specimen (2 valves), dry shell, length 48 mm (Fig. 3) • Murray County, Conasauga River, Lower Kings Bridge; [34.8535, −084.8438]; 16.X.1916; Herbert H. Smith leg.; UF 63733, 3 specimens (6 valves), dry shell, lengths 28–32 mm (Fig. 4).

Additional material examined. UNITED STATES OF AMERICA – **Alabama** • St. Clair County, Coosa River, Ten Island Shoals, just below old lock 2 dam, 3.2 miles south of Greenport [Greensport]; [33.7937, −086.0640]; 2.IX.1956; Herbert D. Athearn; CMNML 20094, 1 specimen (2 valves), dry shell, length 58 mm, height 41.5 mm, width 26 mm. The collection date reported in the original description, 2 August 1956, is an error based on a review of the information recorded by Athearn in his

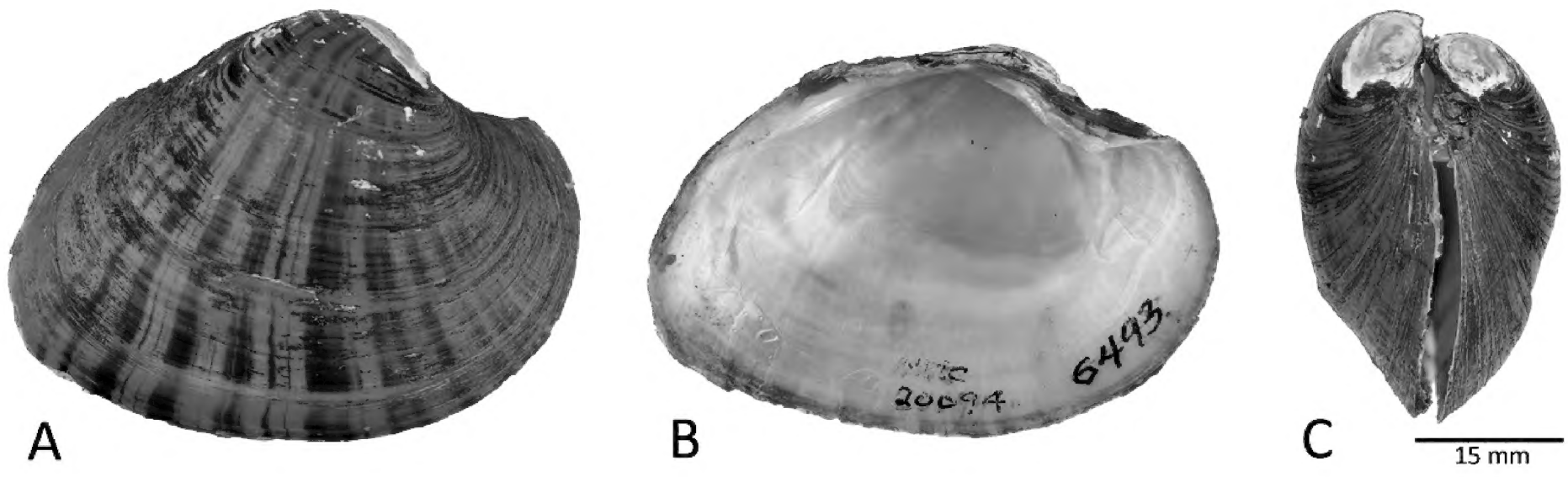

Figure 1. *Alasmidonta mccordi*. CMNML 20094 (holotype), length 58 mm, height 41.5 mm, width 26 mm. Coosa River, Ten Island Shoals, just below old lock and dam 2, 3.2 miles south of Greenport [Greensport], [33.7937, −086.0640], St. Clair County, Alabama, 2 September 1956. **A.** Right valve, external view. **B.** Left valve, internal view. **C.** Both valves, anterior view. Photographs courtesy of Philippe Ste-Marie.

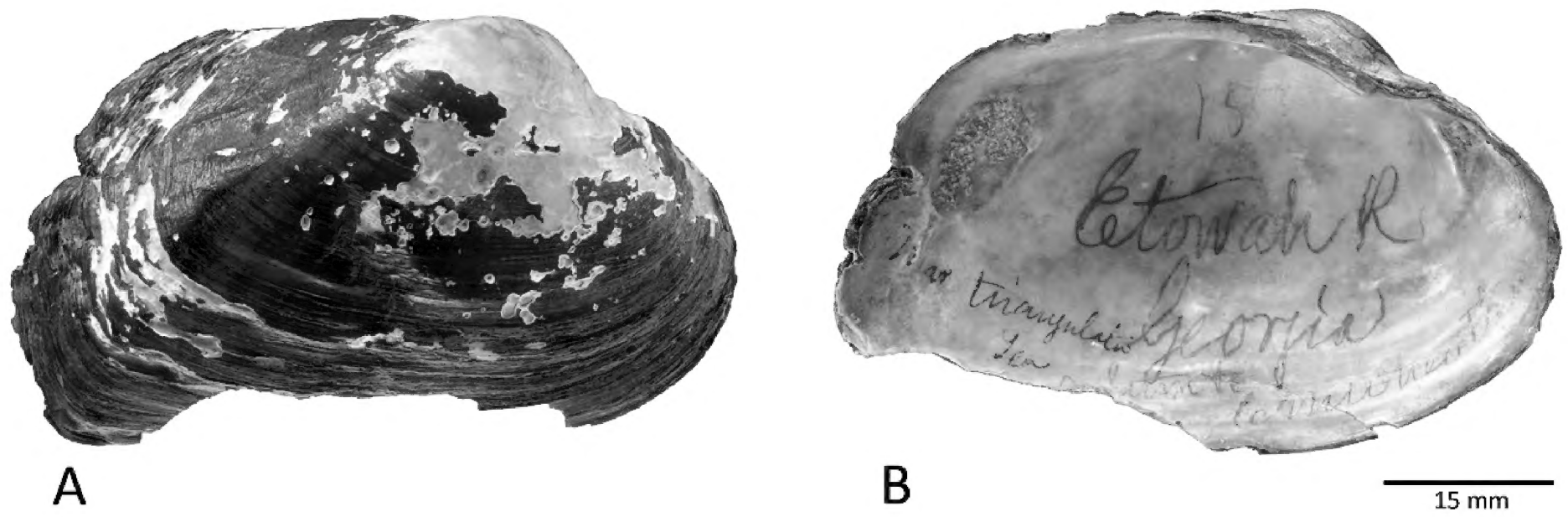

Figure 2. *Alasmidonta mccordi*. ANSP 126760, length 64 mm. Etowah River, Georgia, [1800s], Charles M. Wheatley collection. **A.** Right valve, external view. **B.** Left valve, internal view. © Richard T. Bryant.

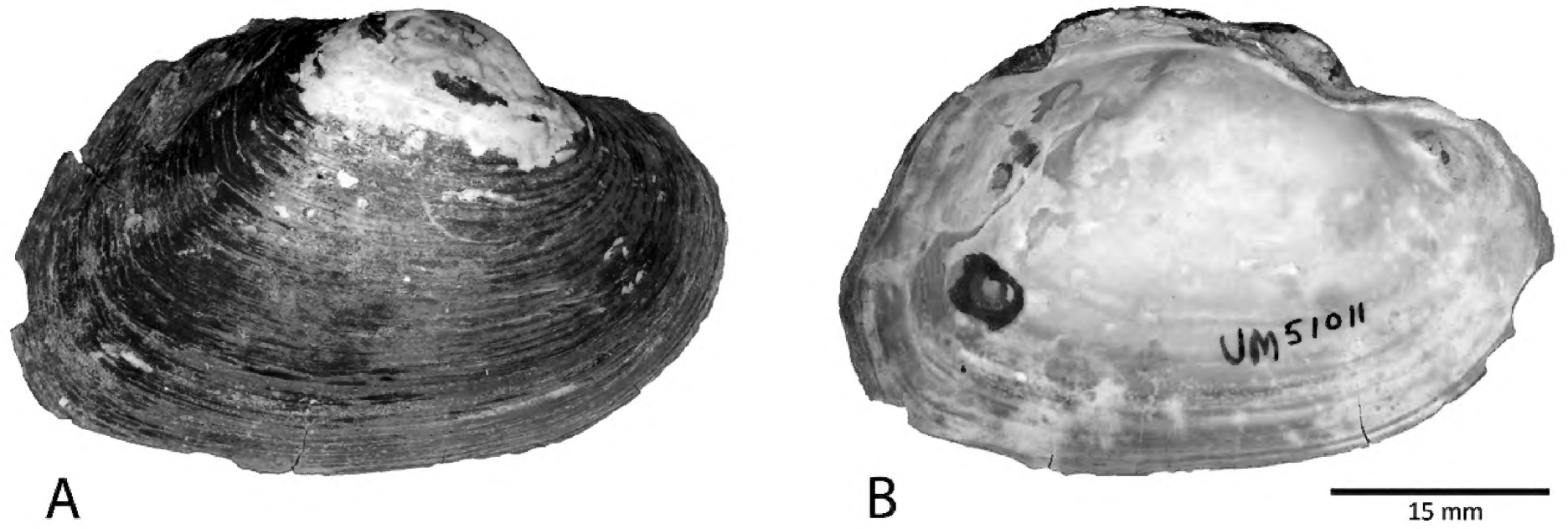

Figure 3. *Alasmidonta mccordi*. UMMZ 51011, length 48 mm. Conasauga River, Tilton, Whitfield County, Georgia, [34.6665, −084.9282], 1930, Calvin Goodrich and Henry van der Schalie. **A.** Right valve, external view. **B.** Left valve, internal view. Photographs courtesy of Taehwan Lee.

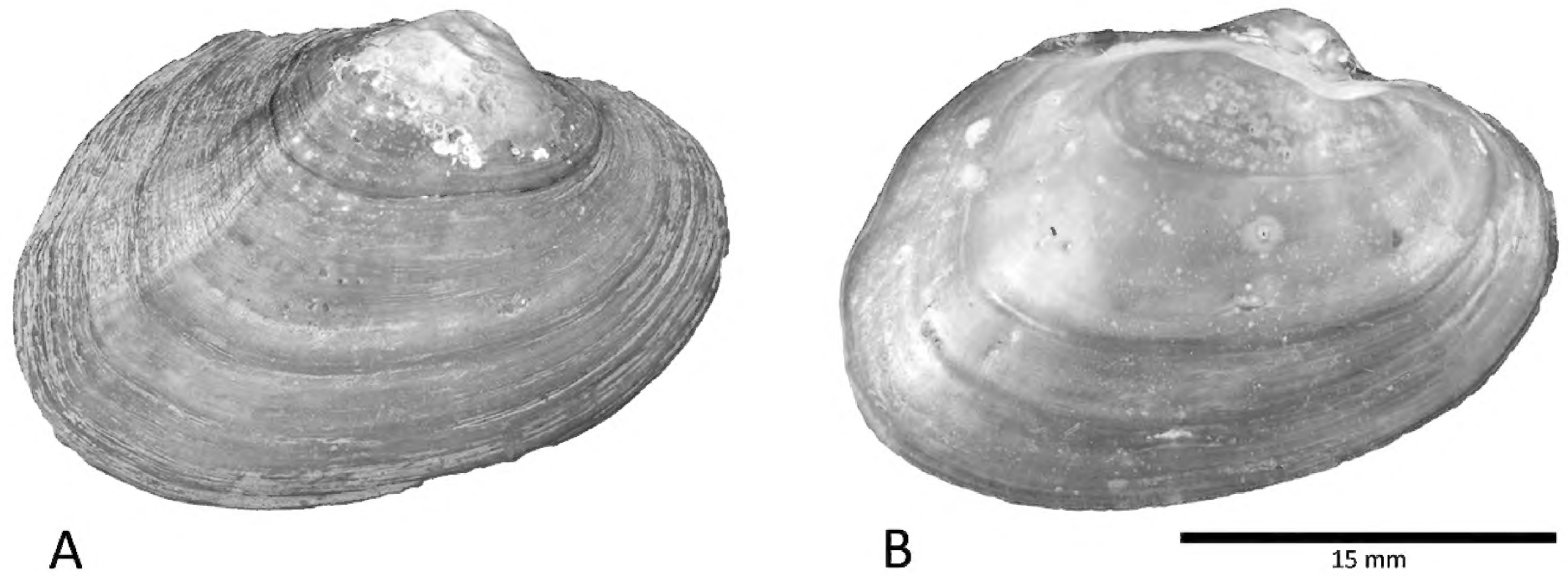

Figure 4. *Alasmidonta mccordi*. UF 63733, length 28 mm. Conasauga River, Lower Kings Bridge, [34.8535, −084.8438], Murray County, Georgia, 16 October 1916. **A.** Right valve, external view. **B.** Left valve, internal view. Photographs courtesy of Zachary Randall.

collection catalog that revealed the specimen was collected 2 September 1956.

Identification. We identified the museum specimens as *Alasmidonta mccordi* based on the conchological characteristics of the type specimen presented in the original description by Athearn (1964) and additional information, illustrations, and photographs in Clarke (1981) and Williams et al. (2008). Important diagnostic characters include the moderately inflated umbos just anterior to the center of the shell and slightly turned forward and presence of an arcuate depression (lunule) just anterior of the umbo. The pseudocardinal teeth, one in the left

valve and two in the right valve, are thin, slightly curved, and located below the lunule. In comparing the recently discovered shells to the type specimen, care was taken to allow for the fact that Athearn (1964: 135) reported the valves of the type specimen were "slightly mis-shapen and the growth lines are not entirely concentric. Apparently during its juvenile stage, this specimen was wedged between two rocks." The degree to which the shell is "misshapen" is very obvious when viewed from the anterior end (Fig. 1). Some of the subtle deviations in shell morphology between the type specimen and the recently discovered specimens (e.g., more pronounced lunule in type) are likely associated with the aberrant "misshapen" shell morphology of the type. Also the type specimen has one pseudocardinal tooth in the left valve and two in the right valve (Clarke 1981), which differs from other specimens that typically have one pseudocardinal in each valve. Variation in this character (number of pseudocardinal teeth in each valve) was noted in several species of *Alasmidonta* by Clarke (1981). The type specimen has green rays on the shell disk that are absent in the five individuals from three upstream localities. In shells of other species of *Alasmidonta*, the presence or absence of rays is often variable, ranging from a yellowish-olive-green periostracum with dark rays to dark olive to black without rays. There is a tendency for unionid shells to become darker with age, often obscuring rays or making them harder to discern.

Distribution. *Alasmidonta mccordi* was the first and only species of *Alasmidonta* to be described from the Mobile Basin. In 1966 the locality of the only known specimen, the holotype, was impounded by a dam resulting in destruction of its habitat. That was the last reach of unimpounded large river habitat in the mainstem Coosa River in Alabama and Georgia. In the absence of any additional material from upstream tributary rivers in Georgia and Tennessee, it was assumed *A. mccordi* was extinct. Our discovery and identification of three additional lots of museum material of *A. mccordi* extends the range of the species into northwest Georgia in the Conasauga and Etowah Rivers. Herein we consider the specimens in these three lots of museum material to validate the occurrence of *A. mccordi* from the Coosa River drainage in Georgia (Fig. 5).

One lot of *Alasmidonta mccordi* (ANSP 126760) is from the Etowah River, Georgia, and was collected in the 1800s. This lot was available to malacologists for a century but was overlooked until Clarke (1981: 81) examined it and concluded that it was possibly *Alasmidonta varicosa* (Lamarck, 1819), an Atlantic Coast species, based on his assumption that the "Locality probably incorrect." This shell was treated by Williams et al. (2008) as an unidentified species of *Alasmidonta* but noted incorrectly that it was not *A. mccordi*. This is the only known record of *A. mccordi* from the Etowah River drainage. This specimen appears to be somewhat more elongated and has a broader posterior slope than the type specimen. This difference is most likely due to the altered shape of the type specimen, which Athearn (1964) suggested was the result of the specimen being wedged between two rocks during the juvenile stage. We think it is highly unlikely that this specimen represents a second species of *Alasmidonta* in the Etowah River.

The provenance of the Etowah River specimen is the University of Pennsylvania's Charles M. Wheatley collection that was donated to the Academy of Natural Sciences of Philadelphia. While Clarke (1981) questioned the locality, it has an inscription inside the left valve that clearly reads "Etowah R. Georgia" and also a comment "near *triangulatus* Lea." The reference to "near *triangulatus*" most likely is an indication that the shell was believed to be different but had a resemblance to what is currently recognized as *Alasmidonta triangulata* (Lea, 1858), a species endemic to the Apalachicola Basin of Alabama, Florida, and Georgia, which lies directly east of the Mobile Basin.

There are two lots of *Alasmidonta mccordi* from the Conasauga River, Georgia. One collection taken at Tilton, Whitfield County, one specimen 48 mm in length, was collected by Henry van der Schalie and Calvin Goodrich in the summer of 1930. The other collection of *A. mccordi*, three specimens 28–32 mm in length, was from Lower Kings Bridge crossing on the Conasauga River, Murray County, collected in 1916 by Herbert H. Smith.

Discussion

Alasmidonta mccordi is known from a total of four localities in the Coosa River drainage of Alabama and Georgia. Only one locality is in the Coosa River proper in Alabama and the remaining three are in tributaries in Georgia. The Coosa River is a large river formed by the confluence of the Oostanaula and Etowah Rivers at Rome, Georgia, and flows southwest for approximately 460 km (286 miles) where it joins the Tallapoosa River, near Wetumpka, Alabama, to form the Alabama River. Potential river kilometers (miles) historically occupied by *A. mccordi* in the Coosa River drainage were calculated, using stream mileage tables (U.S. Army Corps of Engineers 1985), by taking the distance from the most upstream points of occurrence downstream to the Coosa River. The length of the Coosa River from Rome, Georgia, downstream to the type locality was added to the miles of potential habitat of the tributaries. Assuming zero miles for the unknown locality in the Etowah River, the minimum potential riverine habitat occupied was 438 km (272 miles), all located in the Valley and Ridge physiographic province. Potential habitat in the Etowah River may have included the lower reach upstream to just above Cartersville, Georgia, a distance of 72 km (45 miles), which is also located in the Valley and Ridge physiographic province. The upper portion of the Etowah River drainage, above Cartersville, is located in the Blue Ridge physiographic province and characterized by a different substrate and water quality conditions.

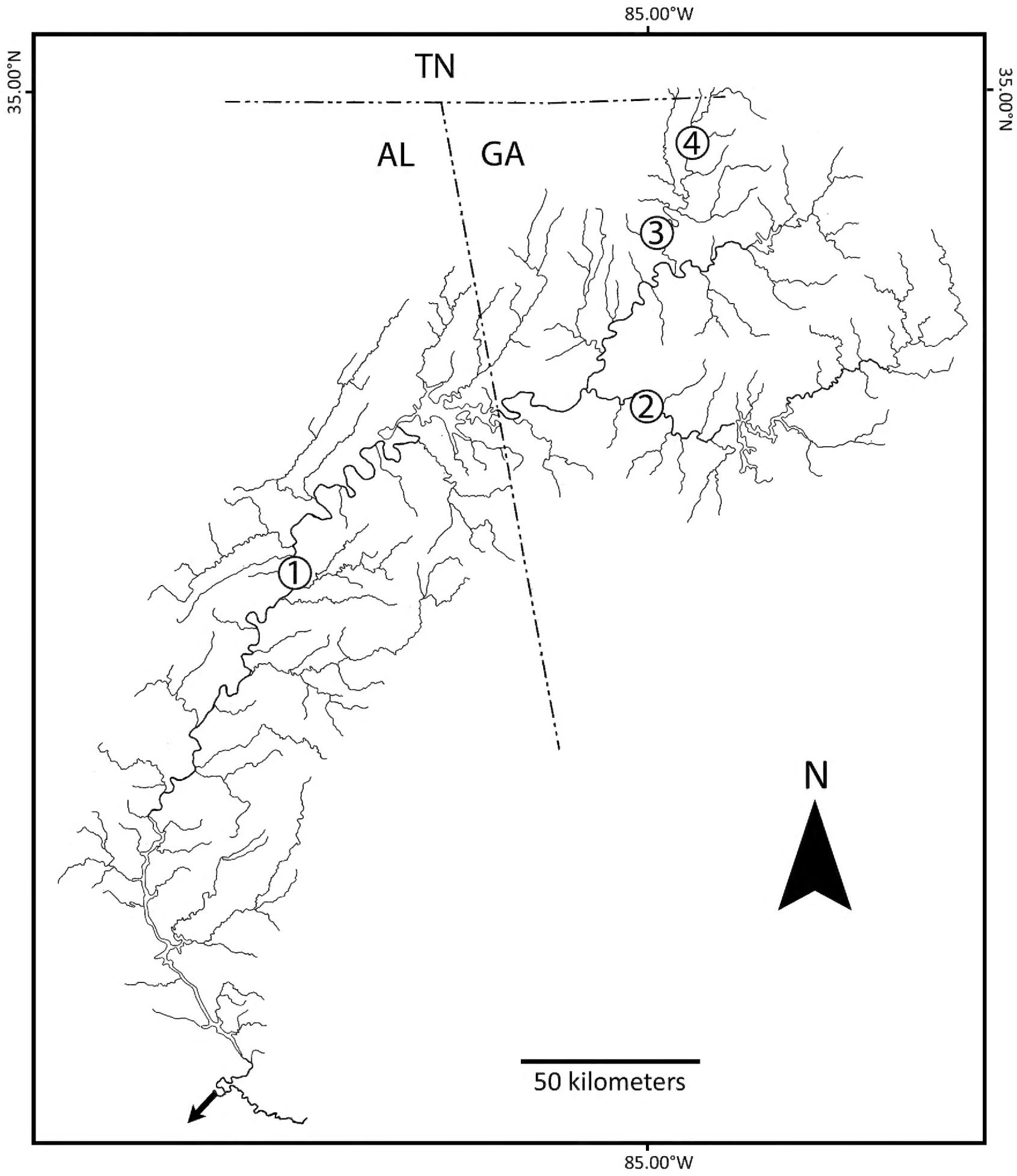

Figure 5. Distribution of *Alasmidonta mccordi* in the Coosa River drainage in Alabama and Georgia. Known localities for *A. mccordi* are (1) Coosa River, type locality, (2) Etowah River, specific locality unknown, (3) Conasauga River near Tilton, and (4) Conasauga River at Lower Kings Bridge.

Mussel collections from the Coosa River drainage in Georgia, which were cataloged into natural history museums, were sporadic prior to 1900. In the early 1900s, it was sampled with increased interest primarily by Herbert H. Smith. From 1903 until 1909, he was employed by a group of conchologists known as the "Syndicate" to collect land and freshwater mollusks primarily in Alabama and Georgia. In 1909 he was employed as the first curator of the Alabama Museum of Natural History at the University of Alabama until his untimely death in 1919 (Goodrich 1922; Walker 1928). During this 16-year period, he made numerous trips to sample headwater tributary rivers and creeks in the upper Coosa River drainage in Georgia and Tennessee, but only once did he encounter what we now recognize as *Alasmidonta mccordi*. Collections of unionids from the headwater rivers in the upper Coosa River drainage were almost nonexistent between 1920 and 1970. Increased frequency of sampling began in the 1970s and has continued to the present with more than 900 sites (JM Wisniewski unpublished data) being sampled without any specimens of *A. mccordi* being detected. Assuming its preferred habitat is similar to related species of *Alasmidonta* (e.g., *A. triangulata* and *A. arcula* (Lea, 1838)), it would have been found in somewhat depositional slack water habitats along the shore adjacent to areas with moderate current. Habitat of a marginal channel along shore but adjacent to areas with moderate current is quite different from

the habitat description where the type specimen was collected in the Coosa River, "a sand and gravelly bottom which was thickly strewn with rock debris from Lock 2 Dam." The site below the dam where the type of *A. mccordi* was found was highly modified and may not represent typical substrate and current conditions. However, the possibility of *A. mccordi* occupying a wider range of habitats cannot be ruled out. It is not known if its rarity can be attributed to sparsity of available habitat or if the upper Coosa River tributaries were substantially altered by clearing of bottom land for agriculture and/or timber harvest in the 1800s and early 1900s leading to habitat destruction.

Passage of the U.S. Endangered Species Acts in 1969 and 1973 served as a stimulus to state and federal agencies as well as conservation groups, scientific organizations, academicians, and individual biologists to evaluate conservation status of all species of wildlife, including freshwater mussels. During the 1970s, the first conservation status assessment of *Alasmidonta mccordi* was reported by Athearn (1970) and Stansbery (1971, 1976) who considered it to be endangered. The U.S. Fish and Wildlife Service (1984) considered *A. mccordi* for listing under provisions of the Endangered Species Act of 1973 but concluded that it was most likely extinct due to the destruction of its only known habitat, presumed to be the impounded mainstem Coosa River. It was also assigned a conservation status of extinct in subsequent assessments (Williams et al. 1993; Lydeard et al. 1999; Garner et al. 2004; Williams et al. 2008). The presumed extinct status of *A. mccordi* was based on the single occurrence in a large river that was subsequently impounded, destroying its habitat.

The paucity of collections of *Alasmidonta mccordi*, known from four sites (six individuals), makes it the rarest known unionid mussel in the Coosa River drainage and one of the rarest in the entire United States. *Alasmidonta robusta* Clarke, 1981, known only from one collection of five individuals from Long Creek, a tributary of the Catawba River, North Carolina, is also presumed to be extinct (Clarke 1981). A related species, *Alasmidonta wrightiana* (Walker, 1901), endemic to the Ochlockonee River in northwest Florida, known from three localities (15 individuals) and last collected in 1931, is also presumed to be extinct (Williams and Butler 1994; Pursifull et al. 2021). The lack of additional known locations for *A. mccordi* has prevented any focused searches for surviving populations in the Coosa River drainage in Alabama and Georgia. While there were no designated projects aimed at locating populations of *A. mccordi*, it was generally understood by biologists sampling mussels in the Coosa River drainage, especially in less disturbed streams in Georgia, that there was always a possibility of it being discovered.

Future research needs for detection of possible surviving populations of *Alasmidonta mccordi* center around the evolving technology of eDNA. Recognizing that hydrologic conditions (e.g., flow, temperature, and pH) are known to have major influence on the volume, distribution, and persistence of eDNA in the water column, spatial and temporal locations of sampling sites should be chosen carefully (Thalinger et al. 2021). Since there is only one species of *Alasmidonta* in the Coosa River system, analysis of eDNA samples that test positive for the genus should represent *A. mccordi*. The Conasauga River has two historical localities for *A. mccordi* and currently supports a number of endangered and threatened mussels and snails. Based on our combined experience sampling mussels in the Conasauga River, this would be the ideal river to begin sampling for eDNA. The lower site, Tilton, is approximately 21 river km (13 miles) upstream from the mouth of the Conasauga River. The uppermost site, Lower Kings Bridge, is located approximately 72 river km (45 miles) above the mouth, which is near the midpoint of the 146 river km (91 miles) length of the Conasauga River. Considering the length of the river channel and various perturbations along its length, it would likely require several sampling sites.

The Conasauga and Coosawattee Rivers join to form the Oostanaula River, which is located entirely in the Valley and Ridge physiographic province. While the Coosawattee River mainstem is highly altered (e.g., entrenched channel, highly variable flows) from the upstream U.S. Army Corps of Engineers Carters Dam, the Oostanaula River is unimpounded along its entire length and continues to support populations of some mussel species. While there are no known records of *Alasmidonta mccordi* from the Oostanaula River, it should not be overlooked as potential habitat for a surviving population. We would recommend including the Oostanaula River in any eDNA project in the upper Coosa River tributaries.

The Etowah River does have a confirmed record of *Alasmidonta mccordi*, but the exact location for the collection is unknown. The lower reach of the river, below Cartersville, is highly altered due to the U.S. Army Corps of Engineers Allatoona Dam. Surveys of the Etowah River between Cartersville and Rome revealed only occasional individuals of widespread mussels known to tolerate disturbed stream environments (JD Williams, JM Wisniewski, and GR Dinkins personal observations). While the Etowah River above Allatoona Dam is in the Blue Ridge physiographic province, it remains relatively unaltered and does support populations of some rare fishes. However, it is likely that few unionids occurred upstream of the impounded portions of Allatoona Dam due to low pH and alkalinity that likely impede growth and survival of mollusks (JM Wisniewski personal observation). While the upper Etowah River would not be a high priority for a mussel eDNA survey, it should be considered if resources are available.

An additional specimen of *Alasmidonta* (OSUM 15113) purported from the Etowah River, Georgia, was identified as "*Alasmidonta mccordi*?" by Williams et al. (2008: figure 13.3). We believe, based on shell thickness,

shell length–height ratio, and structure of the pseudocardinal and lateral teeth, the OSUM specimen either represents an undescribed species of *Alasmidonta* endemic to the Coosa River drainage and may be extinct or is *A. viridis* (Rafinesque, 1820) from a location other than the Etowah River. *Alasmidonta viridis* is native to portions of the Ohio River, upper Mississippi River, and Great Lakes basins. Of the two possibilities, we believe it is more likely to be *A. viridis* from outside the Coosa River drainage.

With the addition of two new rivers and three localities for *Alasmidonta mccordi*, hopefully this will lead to the discovery of a surviving population of this presumed extinct freshwater mussel. In addition to free-flowing riverine habitat, the upper ends of reservoirs should also be included in the surveys. Two related species, *Alasmidonta arcula* and *Alasmidonta undulata* (Say, 1817), are known to inhabit some areas of impoundments. If successful in locating surviving individuals, steps should be taken immediately to develop plans for captive propagation and reintroduction. Recent success in host fish determination for a related species, *Alasmidonta triangulata*, should provide an excellent first step in successful propagation. While the discovery of specimens from three additional sites in two rivers does not change the status from presumed extinct, it does provide impetus for renewed searches for surviving populations.

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Authors' Contributions

Conceptualization: JDW, JMW, GRD. Funding acquisition: GRD. Investigation: JDW, JMW, GRD. Methodology: JDW. Project administration: JDW. Validation: JMW, GRD. Visualization: JDW, JMW, GRD. Writing – original draft: JDW. Writing – review and editing: JMW, GRD.

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